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Aartsen, M.J.; Smits, C.H.M.; van Tilburg, T.G.; Knipscheer, C.P.M.; Deeg, D.J.H.

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Activity in Older Adults: Cause or Consequence of Cognitive Functioning? A Longitudinal Study on Everyday Activities and Cognitive Performance in Older Adults

Marja J. Aartsen,[1] Carolien H. M. Smits,[1] Theo van Tilburg,[1] Kees C. P. M. Knipscheer,[1] and Dorly J. H. Deeg[2]

[1]Department of Sociology and Social Gerontology and [2]Department of Psychiatry and Institute for Research in Extramural Medicine, Vrije Universiteit, The Netherlands.

The impact of three types of everyday activities (i.e., social, experiential, and developmental) on four cognitive functions (i.e., immediate recall, learning, fluid intelligence, and information-processing speed) and one global indicator of cognitive functioning (Mini-Mental State Exam score) over a period of 6 years was studied in a large 55–85 year-old population-based sample ($N = 2{,}076$). A cross-lagged regression model with latent variables was applied to each combination of 1 cognitive function and 1 type of activity, resulting in 15 (3×5) different models. None of the activities were found to enhance cognitive functioning 6 years later when controlling for age, gender, level of education, and health, as well as for unknown confounding variables. Conversely, one cognitive function (i.e., information-processing speed) appeared to affect developmental activity. It is suggested that no specific activity, but rather socioeconomic status to which activities are closely connected, contributes to maintenance of cognitive functions.

RESEARCHERS in the field of cognitive aging agree that, on average, cognitive functioning declines with aging. Cognitive decline may begin after midlife, but most often occurs at higher ages (70 or higher). However, major individual differences in rate and onset of decline are observed (Baltes & Baltes, 1990; Schaie, 1980, 1983). Moreover, maintenance or even improvement of cognitive functioning with aging is found among some persons (Baltes, Dittmann-Kohli, & Dixon, 1986; Korten et al., 1997). Cognitive decline is associated with increased personal discomfort, loss of autonomy, and increasing societal costs. Research on factors affecting cognitive performance may therefore contribute to the design of intervention strategies that can improve the autonomy and well-being of the aging population.

Over the last decades, increasing evidence has been provided for the beneficial effects of contextual variables suggesting possible points of contact for intervention strategies. Leading an active life is suggested to enhance cognitive functioning (Schaie, 1983). This relation is explained by the use of cognitive skills needed to perform activities, especially activities that are cognitively demanding, resulting in maintenance or enhancement of cognitive functioning. Several studies are consistent with this idea (Arbuckle, Gold, & Andres, 1986; Fabrigoule et al., 1995; Hultsch, Hammer, & Small, 1993; Smits, Van Rijsselt, Jonker, & Deeg, 1995). Apart from these cross-sectional studies in which conclusions on causality are limited, a longitudinal study conducted by Gold and colleagues (1995) revealed that being active is related to maintenance of intelligence across 40 years.

Recently, Hultsch, Small, Hertzog, and Dixon (1999) contested the supposed beneficial effect of contextual variables on cognitive functioning. Using longitudinal data collected among 250 middle-aged and older adults, they investigated whether participation in cognitively demanding activities promotes the development and maintenance of cognitive abilities or whether cognitively capable people tend to participate in environments that are cognitively demanding. Both directions of causation were supported by the data. Hultsch and colleagues also demonstrated this reversed causality in the data set used by Gold and colleagues (1995). This finding led to a lively discussion between the two groups of researchers (Hertzog, Hultsch, & Dixon, 1999; Pushkar et al., 1999). The discussion focused on the selection of indicators of an active lifestyle, some methodological differences, and differences in study samples. The first and second issues constitute the starting point for the present study, in which we examined the relation between everyday activities and cognitive functioning in later life.

Regarding the measurement of activities, it is noted that Gold and colleagues (1995) used socioeconomic status (SES) as one of the three indicators of an engaged lifestyle, whereas Hultsch and colleagues (1999) selected a broad range of everyday activities, including physical activities, social activities, hobbies, and novel information-processing activities such as learning a language or playing bridge. We share the concern expressed by Hultsch and colleagues (1999) that level of cognitive functioning, which is associated with SES, moderates the positive relation between engaged lifestyle and cognitive functioning observed by Gold and colleagues (1995). However, the relation between novel information-processing activities and cognitive functioning observed by Hultsch and colleagues (1999) may be the result of an unobserved confounding variable such as level of education. It is not unthinkable that these novel information-processing activities, which were operationalized by playing bridge and learning a language, are related to higher levels of education or SES (Ganzeboom, 1989). Lack of control for level of education may have resulted in spurious relations between activity and cognitive performance. A procedure to deal with confounding variables, even if these variables are unknown (MacCallum, Wegener, Uchino, & Fabrigar, 1993), could have prevented both studies from finding spurious relationships.

Another issue is the specification of all possible directions of causation. In the model used by Gold and colleagues (1995), no reversed causal direction was specified, and hence no reversed causal effect was detected. In contrast, Hultsch and colleagues (1999) specified both directions of causation in two different models. This approach, however, does not reveal whether these effects could still be observed when both directions were implied in one model, or whether one of the two directions was predominant.

In the present study we investigated the extent to which one of the two possible directions of causation was present, or even predominant, in a large population-based sample of older adults, using various types of everyday activities and cognitive functions. We controlled for the effect of age, gender, level of education, and health, as well for the confounding effect of other, unmeasured, variables.

Our first question deals with the direction of causation between different types of everyday activities and cognitive functioning. First the causal effect of activities on cognitive functioning was tested. In line with previous studies (Fabrigoule et al., 1995; Gold et al., 1995) we expected positive effects from everyday activities on cognitive functioning over time (Hypothesis 1). The positive effect of activities on cognitive functioning may be explained by the process of learning generalization (Miller, Slomczynski, & Kohn, 1987). *Learning generalization* means that knowledge and orientations acquired in one situation are generalized or transferred to other situations. For example, people who do intellectually demanding work come to exercise their intellectual abilities not only on the job, but also in their nonoccupational lives.

The idea of learning generalization, however, also pleads for the opposite direction of causation. Individuals who are already at a high level of cognitive functioning may prefer activities that are cognitively demanding. This leads to a competing Hypothesis 1, stating that respondents with good cognitive functioning engage in activities that are cognitively demanding. In line with this is the hypothesis of Hultsch and colleagues (1999), which reads that high-ability individuals lead intellectually active lives until cognitive decline in old age limits their activities.

If everyday activities indeed enhance cognitive functioning, our second question is whether specific activities differ in their impact on cognitive performance. Several studies suggest that specific activities, rather than an activity per se, affect cognitive functioning. Activities suggested to significantly affect cognitive functioning are activities that are cognitively demanding (Hultsch et al., 1993). In line with this are studies of Kohn and Schooler (Kohn & Schooler, 1978; Schooler, Mulatu, & Oates, 1999), stating that substantively complex work improves intellectual functioning. Finally, Arbuckle, Gold, Andres, Schwartzman, and Chaikelson (1992) revealed that activities in which social support is received results in maintenance of cognitive functioning. However, a classification of everyday activities into cognitively demanding or socially supportive activities is not straightforward. Some activities may be both cognitively demanding and supportive, whereas other activities may well differ across individuals in the extent to which the activity is cognitively demanding or supportive. For example, some people may visit a chess match as a spectator because of their interest in chess, whereas others do so to meet their friends. Lawton (1993) argued that a classification that discriminates best between the universe of possible activities is one based on the meaning of the activity. Adapting Lawton's classification, we distinguish social, experiential, and developmental activities. *Social activity* includes three subcategories, that is, social interaction, social status, and service, such as volunteering. *Experiential activity* is characterized by the intrinsic satisfaction of the activity. It includes activities that are engaged in to find relaxation, or relief from social contexts. *Developmental activity*, including intellectual and creative activities, is meant to help oneself become something, or change in some way. This type of activity thus possesses an instrumental component. Applying the concept of cognitive demand to the categorization of Lawton (1993), we expect developmental activity to best reflect activities that are cognitively demanding, and as such enhance cognitive performance. Furthermore, social support is likely to be generated by social activities, hence we expect social activities to also enhance cognitive functioning. As experiential activity is not necessarily cognitively demanding activity, nor activity in which social support is received, we do not expect any effect on cognitive functioning (Hypothesis 2).

Finally, we focused on the extent to which various cognitive functions are enhanced by everyday activities, or whether everyday activities are enhanced by cognitive functions. On the basis of the speed hypothesis of Salthouse (1996) and arguments of Hultsch and colleagues (1993), we expected that information-processing speed would be less sensitive to everyday activities than memory and various types of nonverbal intelligence. Furthermore, as the slowing of information-processing speed precedes decline of higher order cognitive functions, we expected that whenever the level of activity is affected by cognitive functioning, it is most readily seen for information-processing speed (Hypothesis 3).

Methods

Sample

Data were used from the Longitudinal Aging Study Amsterdam (LASA), which is a longitudinal, multidisciplinary research project focusing on autonomy and well-being in the aging population (Deeg, Knipscheer, & Van Tilburg, 1993). The LASA sample is stratified by age and sex, and there was an oversampling of older and male participants at baseline. The sample is drawn from the population registers of 11 municipalities in three culturally distinct geographical areas in The Netherlands. The LASA sample was initially recruited for the study, "Living arrangements and social networks of older adults" (LSN; Knipscheer, De Jong Gierveld, Van Tilburg, & Dykstra, 1995). Since the beginning of the LASA study, three cycles have been conducted with a time interval of approximately 3 years. The first cycle took place between October 1992 and March 1993. Of the 3,805 participants in the LSN sample, 3,107 persons aged 55 to 85 years took part in the first (T_1) LASA cycle (1992/1993). Of the 698 LSN respondents who did not participate in the LASA study, 126 (18%) had died and 134 (19%) were unable to participate in the study because of severe physical and/or mental health problems. Furthermore, 394 (56%) refused to be reinterviewed, and 44 (6%) could not be contacted. In the present study we selected data from the first and third cycles, which yields a 6-year time interval. Of the 3,107 LASA respondents, 2,076 (67% of 3,107) were able to participate in the third (T_3) cycle (1998/1999). Attrition between T_1 and T_3 was caused primarily by mortality (761 persons, 24%). Other reasons for attrition were refusal (160 persons, 5%), frailty (81 persons, 3%), and failure to contact (29 persons, 1%). Attrition, not attributable to mortality, is associated with low cognitive performance, low level of everyday activity, high age, being male, and a lower level of education (all ps $< .001$) at the first LASA cycle, resulting in a selection of respondents who were relatively younger and more highly educated and active, with relatively good cognitive performance. Although our sample is clearly a survival sample, we still had a relatively large proportion (70%) of respondents with one or more chronic disease suggesting sufficient heterogeneity of general health in the study sample. Furthermore, the stratified sampling frame and the sample size guaranteed the inclusion of sufficient men (T_1 49%; T_3 45%), respondents in the highest age category (T_1 $M = 70.8$, $SD = 8.8$; T_3 $M = 74.7$, $SD = 8.3$), respondents with low level of education (T_1 $M = 3.4$, $SD = 2.0$; T_3 $M = 3.5$, $SD = 2.0$), and with low levels of activity (see Table 1).

Both at T_1 and T_3, data on the LASA participants were collected by means of two face-to-face interviews and one self-administered questionnaire. With respect to the variables used in this study, the same instruments were used at T_1 and T_3. Measures of fluid intelligence and general cognitive functioning were assessed during the first face-to-face interview, whereas measures of information-processing speed and memory were part of the second face-to-face interview, which took place 2 to 4 weeks after the first interview. At T_3, respondents born between 1931 and 1937 were not included in the second face-to-face interview, unless they were part of a small group participating in a side study ($n = 124$). As a consequence, the number of respondents ($n = 1352$) completing the memory test and the information processing speed test at T_3 is smaller than for the fluid intelligence test and Mini-Mental State Exam (MMSE) at T_3 ($n = 1874$).

Exogenous Variables

Baseline scores of age, gender, health, and level of education are considered exogenous variables as these are known to be associated with cognitive performance (Brayne, Gill, Paykel, Huppert, & O'Connor, 1995; Gribbin, Schaie, & Parham, 1980; Holland & Rabbitt, 1991; Perlmutter & Nyquist, 1990). Apart from their potentially confounding effect on cognitive performance, age and gender were included because of their use as sample stratification variables. Functional ability was used as an indicator of health. Scores were based on ability to perform three activities: walking up and down a staircase with 15 steps without having to stop, using own or public transportation, and cutting one's own toenails (Kriegsman, Deeg, Van Eijk, Penninx, & Boeke, 1997). The respondents were asked to indicate whether they had difficulty in performing the activity, whether they needed help, or whether they were unable to perform it at all. Functional ability ranged from 0 to 9, with higher test scores indicating better physical functioning. The functional ability index has good reliability (Cronbach's $\alpha = .75$ at T_1). Level of education was assessed by asking the respondent for the highest educational course completed, resulting in a nine-categories variable ranging from 1 (incomplete elementary education) to 9 (university education).

Table 1. Descriptive Statistics of the Study Variables and Test for Significant Difference Between Two Points in Time

	Mean (*SD*)			
Variable	T_1	T_3	*t*	*z*
Age[a]	68.7 (8.3)			
Gender (% Male)[a]	44.6			
Level of education[a]	3.5 (2.0)			
Functional ability score[a]	8.5 (1.2)			
Cognitive functions				
MMSE	27.5 (2.7)	26.9 (3.0)	6.9	
Immediate recall	4.6 (1.7)	4.3 (1.9)	5.2	
Learning	6.0 (2.6)	6.1 (2.2)	−1.6	
Fluid intelligence	18.2 (4.2)	16.0 (6.4)	14.0	
Information-processing speed	23.1 (7.6)	21.3 (7.9)	10.9	
Social activities (% attending)				
Attending church services	30.1	17.8		−7.2
Visiting neighborhood association	9.3	6.5		−2.6
Visiting organizations for helping elderly and handicapped	5.5	4.7		−.9
Experiential activities (1–7)				
Making a trip to the forest, dunes	1.7 (.9)	1.6 (.9)	2.7	
Visiting a cultural institution	2.5 (1.4)	2.3 (1.4)	5.9	
Visiting a café or restaurant	2.2 (1.4)	2.1 (1.4)	3.9	
Developmental activities (% attending)				
Attending a course or study	13.1	6.9		−5.2

Notes: $n = 1126$. There is a row-wise deletion of missing variables. MMSE = Mini-Mental State Exam.

[a]Means and proportions at T_1 presented for respondents still present at T_3.

Endogenous Variables

Everyday activities.—Information was collected on 23 different everyday activities. We first selected those activities in which at least 4% of the respondents were engaged, to ensure sufficient variability in the variables. The selected 16 activities were then assigned to the three main categories of everyday activity—that is, social, experiential, and developmental activity—by eight colleagues of our research team. Agreement on assignment (at least six out of eight raters) was observed for 11 activities, which were used for further analyses.

For social activity three out of five social activities showing the highest intercorrelation were selected: visiting church services (yes/no), visiting neighborhood associations (yes/no), and visiting meetings of an organization for helping older adults, neighbors, or handicapped persons (yes/no). For experiential activity three out of four experiential activities showing the highest intercorrelation were selected: making a trip to the forest, dunes, zoo, or entertainment park; visiting a cultural institution such as a museum, theater, or cinema; and visiting a café or restaurant (all answer categories ranged from 1 [never] to 7 [every day]). For developmental activity two different activities were selected: following an educational course or study during the past 6 months (yes/no), and doing outdoor sports (1 [never] to 7 [every day]). Finally, with the LISREL8 program (Jöreskog & Sörbom, 1993) we tested whether change in the measurement model of everyday activity could be assumed to be a true change of everyday activity. This change, also referred to as alpha change (Golembiewski, Billingsley, & Yeager, 1976), which is the level of change given a constant calibrated instrument and conceptual domain, is assumed to be present when the covariance matrices of the indicators in the measurement model are equal at T_1 and T_3. We therefore performed a two-group analysis for the latent variables experiential, social, and developmental activity, under the assumption of equal covariances at both time points. The models for experiential activity and social activity revealed good fitting models, χ^2 (6, N = 1697) = 13,35, CFI = .99, sRMR = .02, RMSEA = .02, and χ^2 (6, N = 1693) = 8,81, CFI = 1.00, sRMR = .02, RMSEA = .01, respectively. However, for the two indicators of developmental activity, no such model could be found. It was concluded that, although doing outdoor sports and attending educational courses both were rated as indicators of a developmental activity, their content was too different to represent a homogeneous dimension. As attending educational courses best reflects the idea of a cognitively demanding activity, we selected studying as a single indicator of developmental activity.

Cognitive functioning.—The cognitive functions involved in this study were those commonly found to deteriorate with aging—that is, immediate recall and learning—as indicators of memory performance, fluid intelligence, and information-processing speed. They reflect broadly the cognitive functions currently distinguished in the cognitive aging literature (Baltes, 1993; Lindenberger & Baltes, 1997). For comparative reasons we further included the MMSE (Folstein, Folstein, & McHugh, 1975), because of its widespread use as a screening instrument for cognitive functioning.

The MMSE score involves indications of recall, orientation, registration, attention, language, and construction. Scale scores range from 0 to 30. Higher scores on the MMSE indicate better cognitive performance. At T_1, Cronbach's alpha was .69 and at T_3, Cronbach's alpha was .61. Although the alpha we observed is low for a 23-item scale, it is comparable to alphas found in other population-based surveys. Moreover, the MMSE is judged to assess the severity of cognitive impairment and cognitive changes satisfactorily (Tombaugh & McIntyre, 1992).

The 15 Words Test (Saan & Deelman, 1986), derived from the Auditory Verbal Learning Test (Rey, 1964), was chosen for the assessment of immediate recall and learning. The procedure started with a verbal presentation by the interviewer of 15 words. Immediately after the presentation, the respondent was asked to repeat as many words as possible. The same procedure took place three times, using the same 15 words, to obtain an indication of immediate recall (score on the first trial) and learning (average score of the three trials). Subsequently, for a duration of approximately 20 min, the respondent performed a different nonverbal task. After this, the respondent was asked to recall as many words as possible of the 15 Words Test, to obtain an indication of the delayed recall function. The respondent was not prepared for this last trial. For the subsequent cycles, parallel versions of the 15 listed words were used. The different words of the parallel versions are comparable with respect to the frequency of daily occurrence, number of syllables, the stage of life at which they are acquired, and mental imagery. As in many tests involving learning (Lezak, 1995), possible practice effects were observed in the 15 Words Test. Practice effects may have been due to the fact that respondents remembered the delayed recall test, for which they were unprepared at the first measurement cycle. They may therefore have listened more carefully to the words during the third measurement, which resulted in a better overall score. For this reason we used only those indicators of memory performance in our study that showed no or only small mean improvement. The scores on the 15 Words Test consisted of the number of words correctly remembered per trial, resulting in a score range of 0 to 15 for each attempt. The scores on the immediate recall ranged from 0 to 12. The scores on learning ranged from 0 to 14. The bivariate correlation of the score on the first trial at T_1 and the score on the first trial at T_3 was .44. The bivariate correlation for the second trial was .53, and, for the third trial, .54.

Raven's Coloured Progressive Matrices (Raven, Raven, & Court, 1995) was used to measure *fluid intelligence*, or the ability to deal with essentially new information. In pilot studies a high correlation was observed between the sum score of the total test and the sum score of Tests A and B (.96). To save time in the interview, Set Ab was not included in this study. Sets A and B each consisted of 12 pages, each page displaying a different pattern, from which one section was missing. At the bottom of each page, six patterns were printed, and the respondent was asked to choose which of these six patterns best fitted into the missing section. The test score was the number of correctly chosen patterns and ranged from 0 to 24. At T_1, the internal consistency calculated for ordinal variables (KR 20) was .97, and at T_3 KR 20 was .96.

An adaptation of the Coding Task (Savage, 1984) was used to assess information-processing speed. The respondents were presented a sheet on which rows of characters were printed. They were asked to name the character that belongs underneath the printed characters, and to work as quickly and accurately as possible. The correct letter combination could be read at the top of the page. This was repeated in three trials of 1 min each. The score for each trial of the Coding Task consisted of the number of completed combinations. Scores on the first trial were used because of its lowest rate of nonresponse.

Procedure

To overcome problems of reversed causation and confounding variables in research on causality, it is recommended to use a linear structural equations approach, which includes reversed effects and confounding variables, as well as a measurement model to account for errors in the measurement (Zapf, Dormann, & Frese, 1996). Accordingly, we applied a cross-lagged regression model (Bynner, 1994) as in Figure 1 (full model) to evaluate our hypotheses. Observed variables are enclosed in boxes; latent variables, in ellipses.

Figure 1 shows that we estimated cross-lagged effects (shown with straight one-way arrows) from the latent variable everyday activity at T_1 on cognitive performance at T_3 (β_{41}) and from cognitive performance at T_1 on everyday activity at T_3 (β_{32}). The figure further shows the lagged effects of baseline activity on activity at T_3 (β_{31}) and the effect of baseline cognitive performance on cognitive performance at T_3 (β_{42}). In accordance with MacCallum and colleagues (1993), we allowed for residual correlations (shown as curved two-way arrows) among the latent variables at T_1 (ψ_{21}) and among the latent variables at T_3 (ψ_{43}) to control for the effect of unknown confounding variables. The error terms of the indicators of the latent variables social and experiential activity were allowed to correlate over time. No correlated error terms for the single-indicator latent variables (all cognitive variables and developmental activity) were modeled. The error terms of the single indicators were fixed at a specific value to account for the unreliability of the measures (Bollen, 1989; Hayduk, 1987). The fixed values were determined by multiplying the proportion of error variance ($1 - \rho$) of the indicator by the variance of the indicator. Reliability was based on Cronbach's alpha (MMSE), KR 20 (fluid intelligence), and test–retest reliability (immediate recall, learning, and information-processing speed). For developmental activity no such reliability measure was available. We therefore made an arbitrary decision about the amount of error variance for the indicator, on the basis of the idea that attending a course does not perfectly measure cognitively demanding activities. We decided to fix the error variance for attending a course at 30%, which seems a reasonable guess compared with other estimated error variances in the models. Apart from these effects, the direct effects (gammas) from the exogenous variables age, gender, level of education, and functional ability on the latent variables (cognition and activity) at T_1 and T_3 were estimated (arrows not shown in the figure). All effects were standardized.

The right time interval for causality to show up, however, is highly dependent on the characteristics of the relationships. For example, when the relation between cognitive functioning and everyday activity is synchronous, that is, the reaction occurs almost immediately after "exposure," then a time interval of 6 years may be too long. To investigate this possibility, we tested another type of model (see Figure 2) in which the correlation of error terms between the latent variables everyday activity and cognition at T_1 was replaced by two direct cross-sectional effects, all other effects being equal.

The cross-lagged regression models were evaluated using the LISREL8 program. Observations with missing values on any of the variables in one model were excluded, resulting in different numbers of observations across the models. Each combination of one cognitive function and one type of everyday activity was tested in a separate model, resulting in 15 (3×5) different models.

The model shown in Figure 1 was applied to all combinations of cognitive functions and everyday activity, varying only the two cross-lagged effects between the endogenous latent variables everyday activity and cognitive perfor-

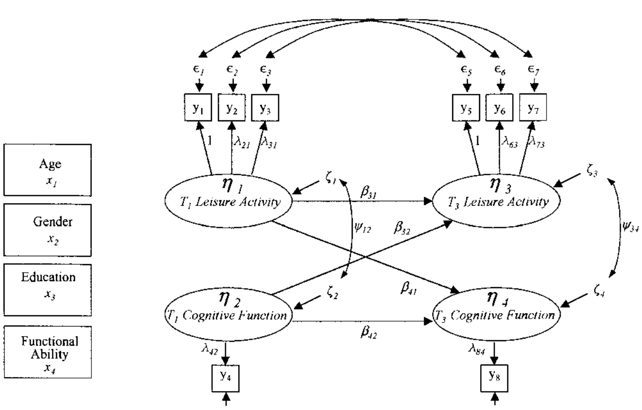

Figure 1. Cross-lagged regression model (full model). The 16 direct effects (gammas) of the exogenous variables age, gender, level of education, and functional ability on the latent variables leisure activity and cognitive function at Time 1 (T_1) and Time 3 (T_3) are not shown in the figure.

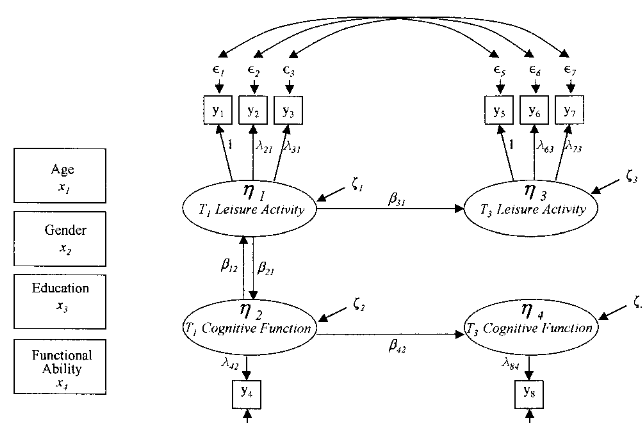

Figure 2. Cross-sectional regression model, error correlates of the latent variables replaced by two direct cross-sectional effects at Time 1 (T_1). The 16 direct effects (gammas) of the exogenous variables age, gender, level of education, and functional ability on the latent variables leisure activity and cognitive function at Time 1 (T_1) and Time 3 (T_3) are not shown in the figure.

mance. This procedure was repeated for the model in Figure 2. Each model was estimated with a step-wise procedure starting with an empty model, which is the full model without the cross-lagged effects β_{41} and β_{32} (see Figure 1) and cross-sectional effects β_{21} and β_{12} (see Figure 2). Subsequently, when it became necessary to obtain a fitting model, we tested both cross-lagged effects separately, as well as their joint effect within one model. As having too many effects included in one model may result in capitalization on chance (overidentification), we selected the most parsimonious model that still fit the data. The significance of the betas was tested by inspection of the *t* values and by evaluating several indicators of fit of the total model, on the basis of criteria described by Jaccard and Wan (1996). When both cross-lagged, or cross-sectional, effects appeared to be significant, predominance of one of the two effects was tested by imposing equality constraints on the betas. When equality constraints on the cross-lagged, or cross-sectional effects resulted in an unacceptable fit of the model, we concluded that the effect with the highest beta was predominant.

Results

In Table 1 the descriptive statistics of all the variables used in the analyses are presented. On average, decline of cognitive functioning was found for the MMSE and in immediate recall, fluid intelligence, and information-processing speed, but not in learning. There was a decrease in the frequency of activities over a time period of 6 years for most of the everyday activities. However, visiting an association for helping older adults did not change.

The estimated gammas reflecting the effects of the exogenous variables on the latent variables revealed that age significantly affects social and developmental activity at T_1 ($\gamma = -.10$ and $-.20$, respectively). At T_3 all types of activity were negatively affected by age ($\gamma = -.30$ for social activity, $-.20$ for experiential activity, and $-.15$ for developmental activity). Cognitive functioning was negatively affected by age at both time points (ranging from $-.22$ to $-.44$). Gender was positively related to everyday activities (ranging from .06 to .18), indicating that women have a higher level of activity. Women had higher scores on cognitive functioning (ranging from .07 to .35), fluid intelligence excepted. Level of education positively affected experiential activity and developmental activity (.48 and .21, respectively), but not social activity. A higher level of education was related to higher levels of cognitive functioning (ranging from .26 to .40). Functional ability was positively related to all cognitive functions (ranging from .07 to .19) and experiential activity (.15), indicating that better health was related to higher levels of cognitive functioning and higher levels of everyday activity. Social and developmental activity were not related to functional ability.

The bivariate correlations among all variables by type of activity are presented in Tables 2–4. According to the first-order correlations for the single indicators, there is almost no association between the indicators of social activity and cognitive functioning (see Table 2). Correlations ranged from $-.06$ to .09. However, indicators of experiential (see Table 3) and developmental activity (see Table 4) correlated positively with cognitive functioning (at T_1 .07 to .21 and .14 to .28, respectively). The next step was to test whether these correlations are sustained when all the other variables assumed to be associated with these relations are controlled for.

The estimates of the lagged and cross-lagged effects, along with the indicators of fit of the models, are presented in Table 5. According to the fit statistics, good fitting models were found. Strong lagged effects (β_{31} and β_{42}) were observed, immediate recall and developmental activity excepted, indicating that activity and cognitive functioning remained fairly stable over the 6 years under study.

Table 2. Bivariate Correlations Between the Exogenous Variables, the Cognitive Variables, and the Indicators of Social Activity at T_1 and T_3 ($n = 1126$)

Social Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Age	—																			
2. Sex	−.02	—																		
3. Level of education	−.10	−.24	—																	
4. Functional ability score	−.25	−.17	.10	—																
5. MMSE score (T_1)	−.21	−.04	.30	.16	—															
6. Immediate recall (T_1)	−.25	.13	.22	.15	.26	—														
7. Learning (T_1)	−.30	.22	.22	.14	.32	.80	—													
8. Fluid intelligence (T_1)	−.28	−.09	.35	.18	.42	.26	.30	—												
9. Information-processing speed (T_1)	−.34	.00	.40	.19	.42	.30	.39	.48	—											
10. Church attendance (T_1)	.03	−.03	−.02	.03	−.02	−.04	−.04	−.02	−.06	—										
11. Neighborhood association (T_1)	−.05	−.06	.00	.02	−.01	−.01	−.02	−.04	.00	.05	—									
12. Helping elderly (T_1)	−.11	.07	−.02	.06	.05	.05	.05	.06	.09	.20	.03	—								
13. MMSE score (T_3)	−.32	−.01	.30	.28	.51	.32	.29	.40	.49	.00	.03	.07	—							
14. Immediate recall (T_3)	−.30	.11	.23	.12	.28	.41	.47	.32	.34	.05	.00	.06	.37	—						
15. Learning (T_3)	−.40	.19	.22	.15	.30	.47	.59	.34	.40	.05	.01	.08	.46	.86	—					
16. Fluid intelligence (T_3)	−.39	−.08	.34	.20	.38	.27	.32	.62	.48	−.08	.03	.03	.43	.29	.36	—				
17. Information-processing speed (T_3)	−.42	.00	.39	.21	.44	.32	.41	.49	.78	−.05	−.01	.08	.53	.43	.51	.52	—			
18. Church attendance (T_3)	−.08	.05	.01	.02	.03	.03	.02	.01	−.04	.56	.03	.17	.03	.11	.11	−.01	−.02	—		
19. Neighborhood association (T_3)	−.09	−.06	−.02	.05	−.02	.01	−.01	−.03	−.03	.05	.32	.03	.01	.02	.03	.01	.00	.09	—	
20. Helping elderly (T_3)	−.17	.09	−.04	.04	.04	.09	.10	.07	.04	.13	.03	.29	.07	.05	.09	.06	.07	.17	.04	—

Notes: Missing cases are deleted per type of activity. MMSE = Mini-Mental State Exam.

Table 3. Bivariate Correlations Between the Exogenous Variables, the Cognitive Variables, and the Indicators of Experiential Activity at T_1 and T_3

Experiential Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Age	—																			
2. Gender	−.02	—																		
3. Level of education	−.10	−.24	—																	
4. Functional ability score	−.25	−.17	.10	—																
5. MMSE score (T_1)	−.21	−.04	.30	.16	—															
6. Immediate recall (T_1)	−.25	.13	.22	.15	.26	—														
7. Learning (T_1)	−.30	.22	.22	.14	.32	.80	—													
8. Fluid intelligence (T_1)	−.28	−.09	.35	.18	.42	.26	.30	—												
9. Information-processing speed (T_1)	−.34	.00	.40	.19	.42	.30	.39	.48	—											
10. Visiting cultural institution (T_1)	−.02	.04	.37	.09	.21	.18	.17	.20	.24	—										
11. Trip to forest, dunes, etc. (T_1)	−.11	−.10	.12	.15	.11	.10	.07	.12	.16	.23	—									
12. Visiting cafe or restaurant (T_1)	−.01	−.07	.20	.11	.09	.09	.07	.13	.15	.30	.26	—								
13. MMSE score (T_3)	−.32	−.04	.30	.21	.51	.32	.39	.40	.49	.18	.16	.10	—							
14. Immediate recall (T_3)	−.30	.11	.23	.12	.28	.41	.47	.32	.34	.19	.06	.09	.37	—						
15. Learning (T_3)	−.40	.19	.22	.15	.30	.47	.59	.34	.40	.18	.06	.06	.46	.86	—					
16. Fluid intelligence (T_3)	−.39	−.08	.34	.20	.38	.27	.32	.62	.48	.16	.14	.14	.43	.29	.36	—				
17. Information-processing speed (T_3)	−.42	.00	.39	.21	.44	.32	.41	.49	.78	.24	.13	.15	.53	.43	.51	.52	—			
18. Visiting cultural institution (T_3)	−.14	.05	.35	.10	.16	.16	.17	.21	.26	.60	.17	.22	.20	.20	.21	.20	.29	—		
19. Trip to forest, dunes, etc. (T_3)	−.19	−.10	.10	.14	.09	.08	.08	.13	.14	.22	.38	.15	.17	.11	.11	.17	.20	.30	—	
20. Visiting cafe or restaurant (T_3)	−.12	−.05	.24	.11	.14	.11	.10	.18	.17	.26	.23	.52	.12	.12	.11	.19	.20	.26	.27	—

Notes: $n = 1126$. MMSE = Mini-Mental State Exam.

Hypothesis 1 specified that positive cross-lagged effects are to be expected from everyday activities on cognitive functioning over time. With respect to this hypothesis, the cross-lagged effects β_{41} were considered. None of the 15 possible cross-lagged effects of everyday activity on cognition reached the level of significance, suggesting that there is no cross-lagged effect of the level of everyday activity on cognitive functioning over a time period of 6 years. We rejected the first hypothesis.

Our competing hypothesis stated that positive cross-lagged effects are to be expected of cognitive functioning on everyday activities, at least for activities that can be viewed as being cognitively demanding. With respect to this hypothesis, the cross-lagged effects β_{32} were considered. In one of the five models involving developmental activity, which is viewed as a cognitively demanding activity, a positive cross-lagged effect ($\beta = .14$) of cognitive functioning on developmental activity was observed. We may conclude that with respect to information-processing speed the competing hypothesis should not be rejected. However, no evidence was found for other aspects of cognitive functioning.

Hypothesis 2 specified that developmental activity and social activity enhance cognitive performance. However, as we observed already, no cross-lagged effects were present. Thus, the expected positive effects of social and developmental activity on cognitive functioning are clearly not supported by the data. We therefore rejected our second hypothesis.

Hypothesis 3 focused on the extent to which cognitive functions are differently affected by everyday activities and whether information-processing speed was more predictive

Table 4. Bivariate Correlations Between the Exogenous Variables, the Cognitive Variables, and the Indicators of Developmental Activity at T_1 and T_3

Developmental Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Age	—															
2. Gender	−.02	—														
3. Level of education	−.10	−.24	—													
4. Functional ability score	−.25	−.17	.10	—												
5. MMSE score (T_1)	−.21	−.05	.30	.16	—											
6. Immediate recall (T_1)	−.25	.13	.22	.15	.26	—										
7. Learning (T_1)	−.30	.22	.22	.14	.32	.80	—									
8. Fluid intelligence (T_1)	−.28	−.09	.35	.18	.42	.26	.30	—								
9. Information-processing speed (T_1)	−.34	.00	.40	.19	.42	.30	.39	.48	—							
10. Study or educational course (T_1)	−.19	.08	.20	.09	.18	.18	.21	.14	.20	—						
11. MMSE score (T_3)	−.32	.04	.30	.21	.51	.32	.39	.40	.49	.17	—					
12. Immediate recall (T_3)	−.29	.11	.23	.12	.28	.41	.47	.32	.34	.16	.37	—				
13. Learning (T_3)	−.40	.19	.22	.15	.30	.47	.59	.34	.40	.20	.45	.86	—			
14. Fluid intelligence (T_3)	−.39	−.08	.34	.20	.38	.27	.32	.62	.48	.14	.43	.29	.36	—		
15. Information-processing speed (T_3)	−.42	.00	.39	.21	.44	.32	.41	.49	.78	.21	.53	.43	.51	.52	—	
16. Study or educational course (T_3)	−.15	.04	.17	.07	.13	.08	.14	.14	.22	.30	.16	.12	.15	.15	.23	—

Notes: $n = 1125$. MMSE = Mini-Mental State Exam.

of everyday activity than other cognitive functions. It was expected that, of the distinguished cognitive functions, information-processing speed would be least affected by everyday activities and would have the largest effect on everyday activities. The first part of this hypothesis was already rejected, and we therefore focused on the last part of the hypothesis, stating that information-processing speed has the largest effect on everyday activities. We observed a positive effect (.14) of information-processing speed on developmental activity, which is in line with our hypothesis.

None of our expectations were supported by the data, except for the effect of speed on developmental activity. One of the reasons for a lack of significant effects may be the length of the time lag. We therefore applied the second model (from Figure 2), in which the error correlation between the latent variables everyday activity and cognitive function was replaced by two direct effects (β_{12} and β_{21}) to test for a possible synchronous effect between everyday activities and cognitive functions. The results of the additional analyses indicated that the idea of synchronicity does not hold. None of the cross-sectional effects at T_1 were significant.

In sum, our study could not provide evidence about a causal effect of everyday activities on cognitive functioning or the other way around. The only effect found (i.e., the effect of information-processing speed on developmental activity) is in favor of the reversed causal hypothesis, stating that respondents with good cognitive functioning prefer cognitively demanding activities. One of the reasons for these small effects compared with other studies in this field may be that we controlled for the effect of unknown confounding variables. Without such a control, the relation between level of activity and cognitive functioning observed in other studies may be the result of spurious relationships. To illustrate that these effects can be observed, we removed the error correlations between the latent variables at T_1 and T_3 and reanalyzed all 15 models. This revealed additional significant cross-lagged effects from experiential activities on MMSE (.08), immediate recall (.12), and information-processing speed (.06), and one from social activity on learning (.09). These four effects suggest that everyday activities enhance cognitive functioning over time. However, as these effects are the result of fixing the residual correlation at T_1 (ψ_{12}) and T_3 (ψ_{34}), they reflect spurious effects. A fifth cross-lagged effect (.06) appeared for MMSE on developmental activity, which seems to confirm that the reversed causal direction is also a spurious effect.

Discussion

The present longitudinal study focused on the causal effects between everyday activities and cognitive performance in a large population-based sample of older adults. We found little evidence of either of the causal effects. None of the activities were found to enhance cognitive functioning 6 years later when we controlled for age, gender, level of education, and health, as well as for unknown confounding variables. Conversely, one cognitive function (i.e., information-processing speed) appeared to affect developmental activity. Before discussing our findings, we address some limitations in our study design.

Table 5. Fit Statistics and Standardized Regression Effects of the 15 Cross-Lagged Models, Controlling for Age, Gender, Level of Education, and Functional Ability

		Lagged		Cross-Lagged		Cross-Sectional		Fit Statistics				
Model Variables	n[a]	β_{31}	β_{42}	β_{41}	β_{32}	β_{21}	β_{12}	χ^2 (df)	RMSEA	sRMR	GFI	CFI
Social Activity												
MMSE	1693	.74	.68					58.21 (31)	.02	.02	.99	.99
Immediate recall	1186	.73	.47					57.17 (31)	.03	.03	.99	.99
Learning	1187	.73	.74					59.70 (31)	.03	.03	.99	.99
Fluid intelligence	1639	.76	.53					57.17 (31)	.02	.02	.99	.99
Information-processing speed	1152	.76	.82					53.62 (31)	.03	.03	.99	.99
Experiential Activity												
MMSE	1697	.71	.67					163.90 (31)	.05	.03	.98	.97
Immediate recall	1185	.73	.48					142.16 (31)	.05	.04	.98	.96
Learning	1186	.73	.74					135.62 (31)	.05	.04	.98	.97
Fluid intelligence	1644	.71	.53					164.41 (31)	.05	.03	.98	.97
Information-processing speed	1153	.72	.81					129.02 (31)	.05	.03	.98	.97
Developmental Activity												
MMSE	1697	.40	.67					1.83 (2)	.00	.00	1.00	1.00
Immediate recall	1185	.37	.48					1.88 (2)	.00	.01	1.00	1.00
Learning	1186	.38	.74					0.19 (2)	.00	.00	1.00	1.00
Fluid intelligence	1644	.41	.53					1.54 (2)	.00	.00	1.00	1.00
Information-processing speed	1153	.36	.81		.14			0.82 (1)	.00	.00	1.00	1.00

Notes: MMSE = Mini-Mental State Exam; RMSEA = root mean square error of approximation; sRMR = standardized root mean square residual; GFI = goodness-of-fit index; CFI = comparative fit index.

[a]Differences in *ns* are mainly caused by the exclusion of most of the respondents born between 1931 and 1937 at follow up from measures of learning, immediate recall, and information-processing speed.

One of the problems we encountered was that attrition has been selective, leaving a relatively younger sample of respondents. However, because of an over-sampling of men and older persons at baseline, the final sample still showed sufficient variability in the study variables, which alleviated the biasing influence of attrition. Furthermore, a study period of 6 years may be too short to demonstrate substantial effects between everyday activities and cognitive functioning. However, increasing the study period undeniably enlarges the biasing impact of selective attrition of respondents. Moreover, the fact that the stability of both cognitive functions and everyday activities was rather high further limited the possibility of finding substantial cross-lagged effects. Finally, only one activity supposed to be cognitively demanding, namely, following a course or study, was included in the analysis. Although this indicator is considered an outstanding example of a cognitively demanding activity, the selection of other cognitively demanding variables may have yielded different results.

Although several studies report positive effects of an active lifestyle on cognitive functioning, our study did not provide evidence for this supposed causality. Regarding the type of cognitive function affected, our findings do not contradict the results reported by Gold and colleagues (1995), as they only found positive effects on crystallized intelligence, and not on indicators of fluid intelligence, which were the only cognitive functions we selected in our study. In the study of Hultsch and colleagues (1999), positive effects of novel information processing and change in information processing were found on working memory, which has a fluid component. However, as working memory was reported to have a high loading on fact recall (.89), which has a crystallized component, we suggest that the positive findings reported by Hultsch and colleagues may be valid for crystallized intelligence, but not for fluid intelligence.

The positive effects of experiential activities on cognitive functions that we found as a result of removing the error correlates between the latent variables cognition and activity point toward the existence of an underlying concept that causes spurious relations between experiential activities and maintenance of cognitive functioning. As this concept is not further specified, we can only speculate on its nature. However, the positive correlation between experiential activities and level of education (see Table 3) makes it likely that this concept has much in common with SES. SES is not only related to cognitive functioning, but also to specific activities (Ganzeboom, 1989). The partial support for our hypothesis stating that respondents with good cognitive functioning engage in activities that are cognitively demanding is in line with this suggestion. SES is related to a variety of living conditions and lifestyles (Bond & Coleman, 1993), such as drinking and smoking behavior and involvement in sports (Tuinstra, Groothoff, Van den Heuvel, & Post, 1998). It is found that higher SES decreases the risk of functional decline during later life (Boult, Kane, Louis, Boult, & McCaffrey, 1994). Analogous to this finding, a cumulative effect of living conditions and lifestyles over the life course on cognitive decline could exist. In sum, we suggest that not the activity in itself, but rather specific lifestyles and living conditions to which the types of activities engaged in are closely connected, may in fact be responsible for the positive relation between specific activities and cognitive functioning.

The positive effect of information-processing speed on developmental activity indicates that our study is mostly in favor of Hultsch and colleagues (1999), who stated that high-ability people lead intellectually active lives. Whether or not decline in cognitive functions results in the limitation of activities remains an open question.

Further research on the relation between activities and maintenance of cognitive functioning may benefit from a focus on different aspects of living conditions and lifestyles. Therefore, although Lawton's categorization based on the meaning of the activity (Lawton, 1993) facilitated a selection of various types of everyday activities, our results indicate that a more fruitful categorization may focus on living conditions and lifestyle. This may shed new light on the underlying mechanisms related to changes of cognitive functioning in old age.

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Address correspondence to Marja Aartsen, Department of Sociology and Social Gerontology, De Boelelaan 1081c, 1081 HV Amsterdam, The Netherlands. E-mail: mj.aartsen@scw.vu.nl

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